US009479756B2

(12) **United States Patent**
Hayakawa

(10) **Patent No.: US 9,479,756 B2**
(45) **Date of Patent: Oct. 25, 2016**

(54) **STEREO CAMERA DEVICE**

(71) Applicant: **Hitachi Automotive Systems, Ltd.**, Hitachinaka-shi, Ibaraki (JP)

(72) Inventor: **Jun Hayakawa**, Hitachinaka (JP)

(73) Assignee: **Hitachi Automotive Systems, Ltd.**, Hitachinaka-shi (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/783,354**

(22) PCT Filed: **Mar. 5, 2014**

(86) PCT No.: **PCT/JP2014/055535**

§ 371 (c)(1),
(2) Date: **Oct. 8, 2015**

(87) PCT Pub. No.: **WO2014/167918**

PCT Pub. Date: **Oct. 16, 2014**

(65) **Prior Publication Data**

US 2016/0057403 A1 Feb. 25, 2016

(30) **Foreign Application Priority Data**

Apr. 9, 2013 (JP) 2013-081166

(51) **Int. Cl.**

H04N 13/02	(2006.01)
H05K 9/00	(2006.01)
H04N 5/225	(2006.01)
H04N 5/357	(2011.01)
G03B 17/02	(2006.01)

(52) **U.S. Cl.**

CPC ***H04N 13/0203*** (2013.01); ***H04N 5/2252*** (2013.01); ***H04N 5/357*** (2013.01); ***H04N 13/0239*** (2013.01); ***H05K 9/0037*** (2013.01); *G03B 17/02* (2013.01); *H04N 2213/001* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0329017 A1 12/2013 Hayakawa et al.

FOREIGN PATENT DOCUMENTS

JP	5-129790 A	5/1993
JP	2005-229431 A	8/2005
JP	2006-5385 A	1/2006
JP	2006-210742 A	8/2006
JP	2012-186574 A	9/2012

OTHER PUBLICATIONS

International Search Report (PCT/ISA/210) issued in PCT Application No. PCT/JP2014/055535 dated Apr. 22, 2014 with English translation (five pages).

Primary Examiner — Roberto Velez
Assistant Examiner — Stephen Coleman
(74) *Attorney, Agent, or Firm* — Crowell & Moring LLP

(57) **ABSTRACT**

The present invention prevents adverse effects on an external device due to radiation noise from a signal line. A stereo camera device is provided with: a case; a first image-capturing unit provided at one end in a longitudinal direction of the case; a second image-capturing unit provided at the other end; a circuit board provided inside the case, a processing circuit connected to each of the first image-capturing unit and the second image-capturing unit by a signal line being mounted on the circuit board, and a connector for outputting a signal processed by the processing circuit to an external apparatus being disposed on the circuit board; and a partition member for partitioning the inside of the case into a plurality of spaces along the longitudinal direction at a first interval that corresponds to a frequency bandwidth in which radiation noise from the signal line is suppressed.

4 Claims, 7 Drawing Sheets

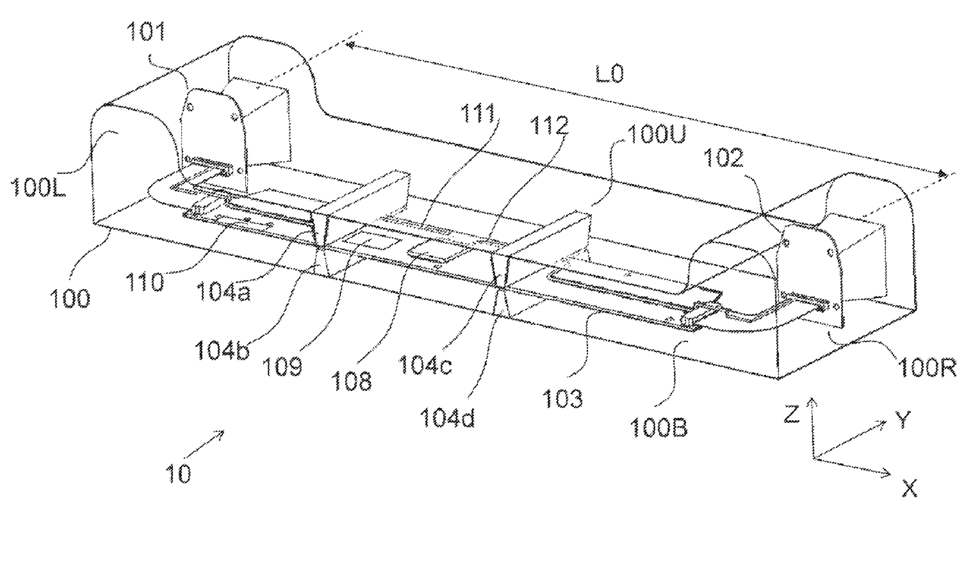
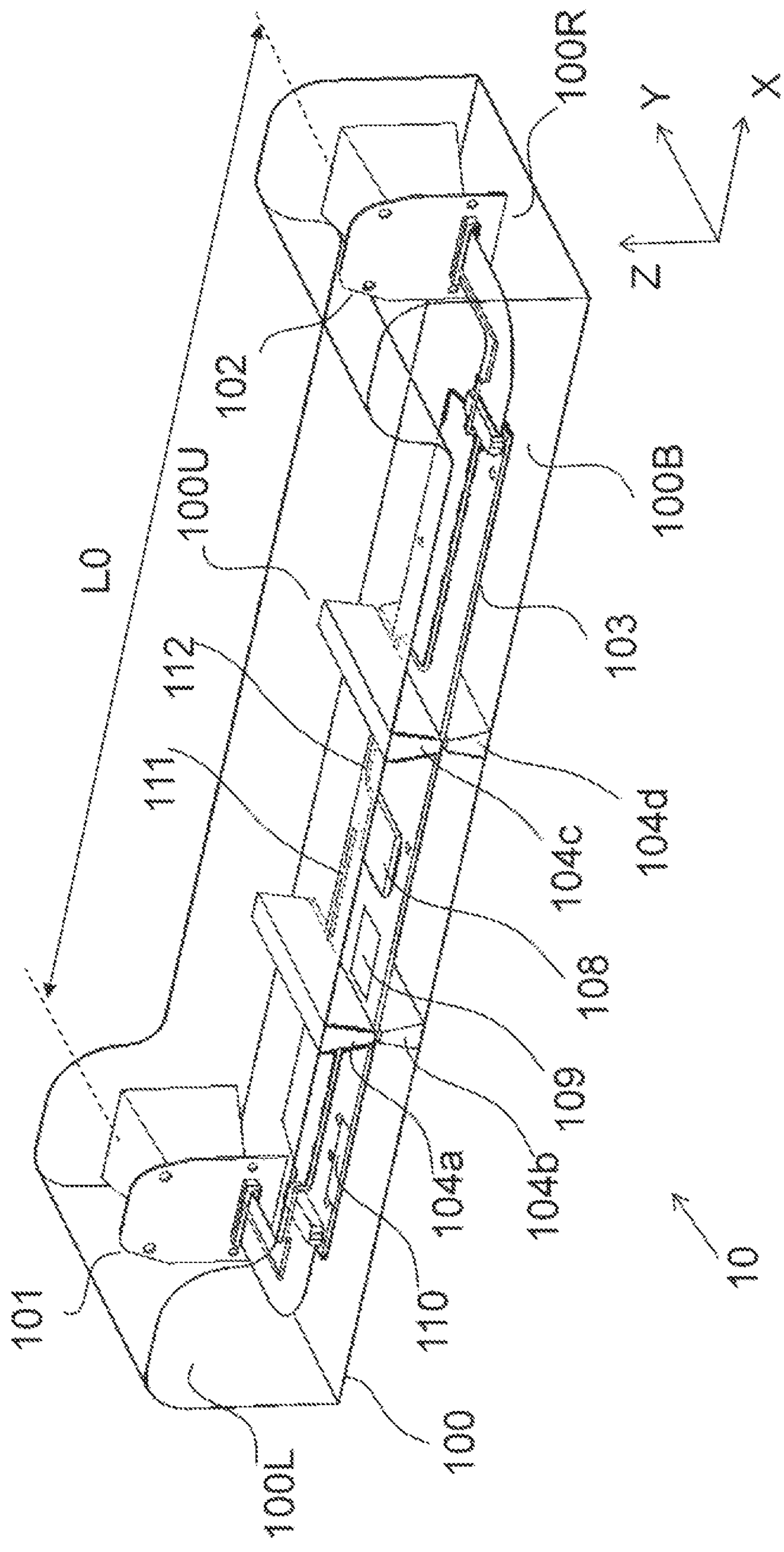


FIG. 1


L0
100R
Y
X
Z
102
100U
100B
103
112
111
104c
104d
108
109
104a
104b
110
101
100
100L
10

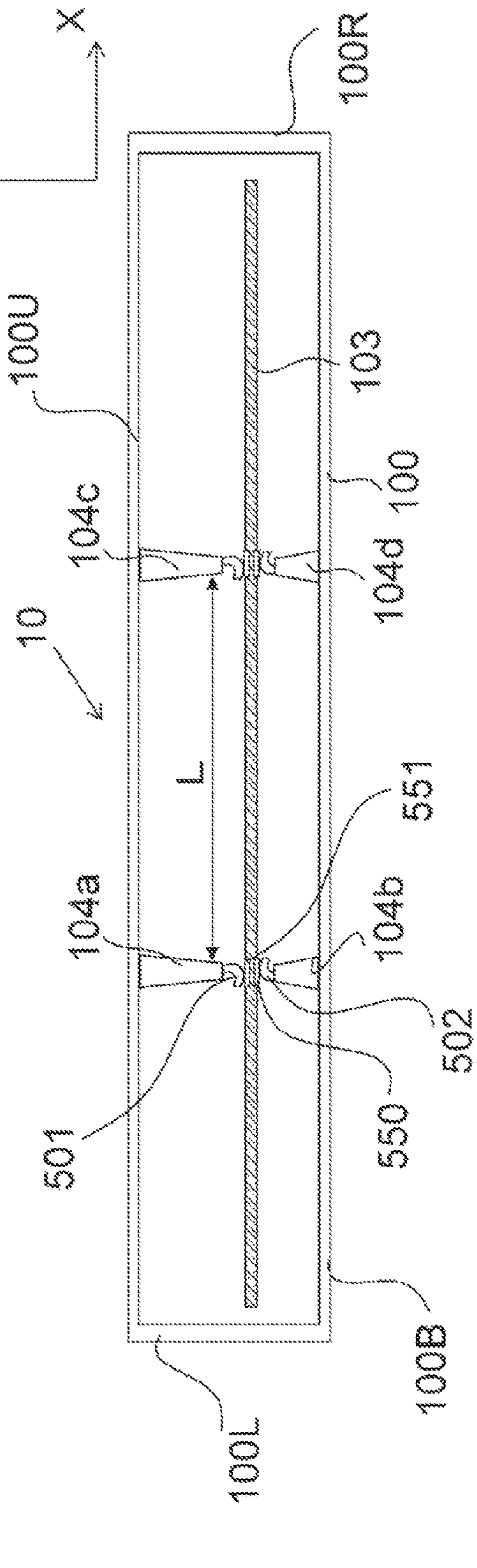

X
Z
100R
100U
103
100
104c
104d
10
L
551
104a
104b
502
501
550
100B
100L

FIG. 2A

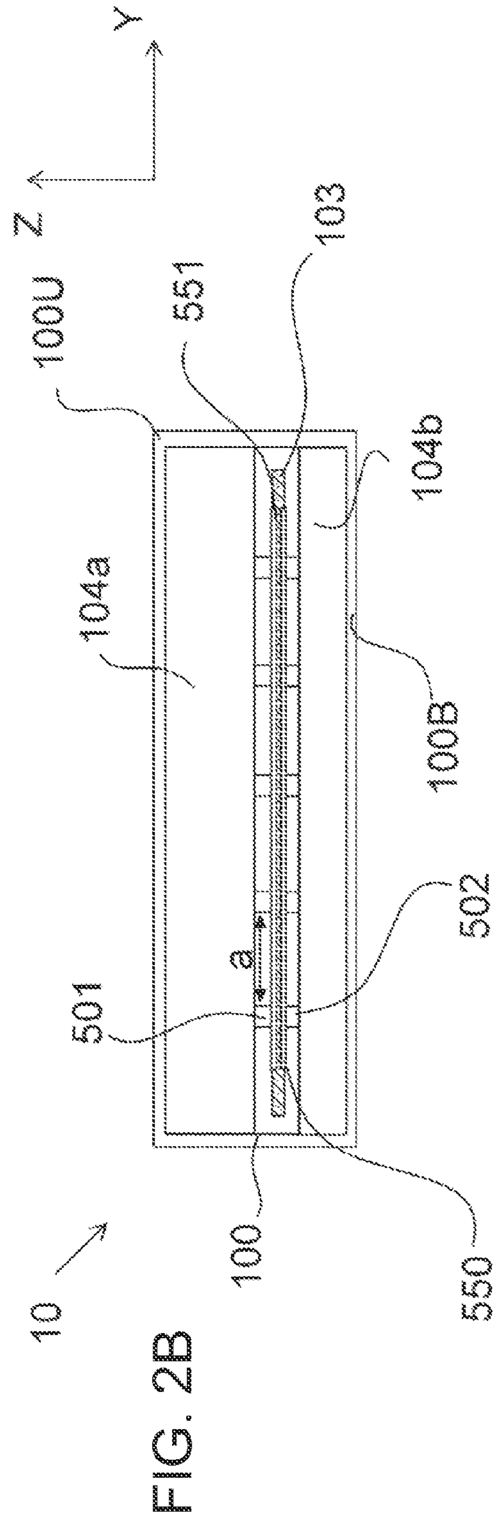

Y
Z
103
551
100U
104b
104a
100B
502
a
501
100
550
10

FIG. 2B

FIG. 3

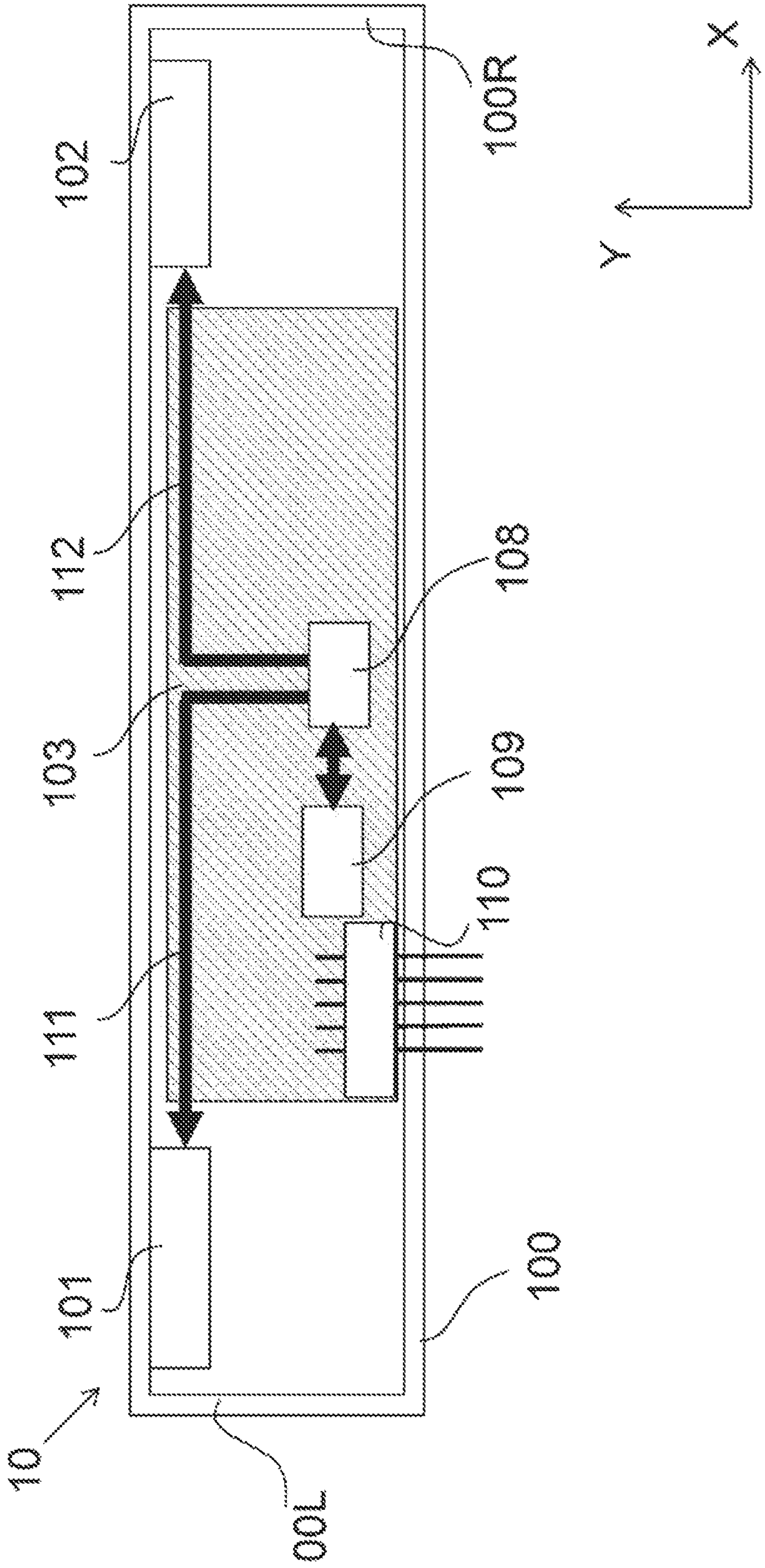
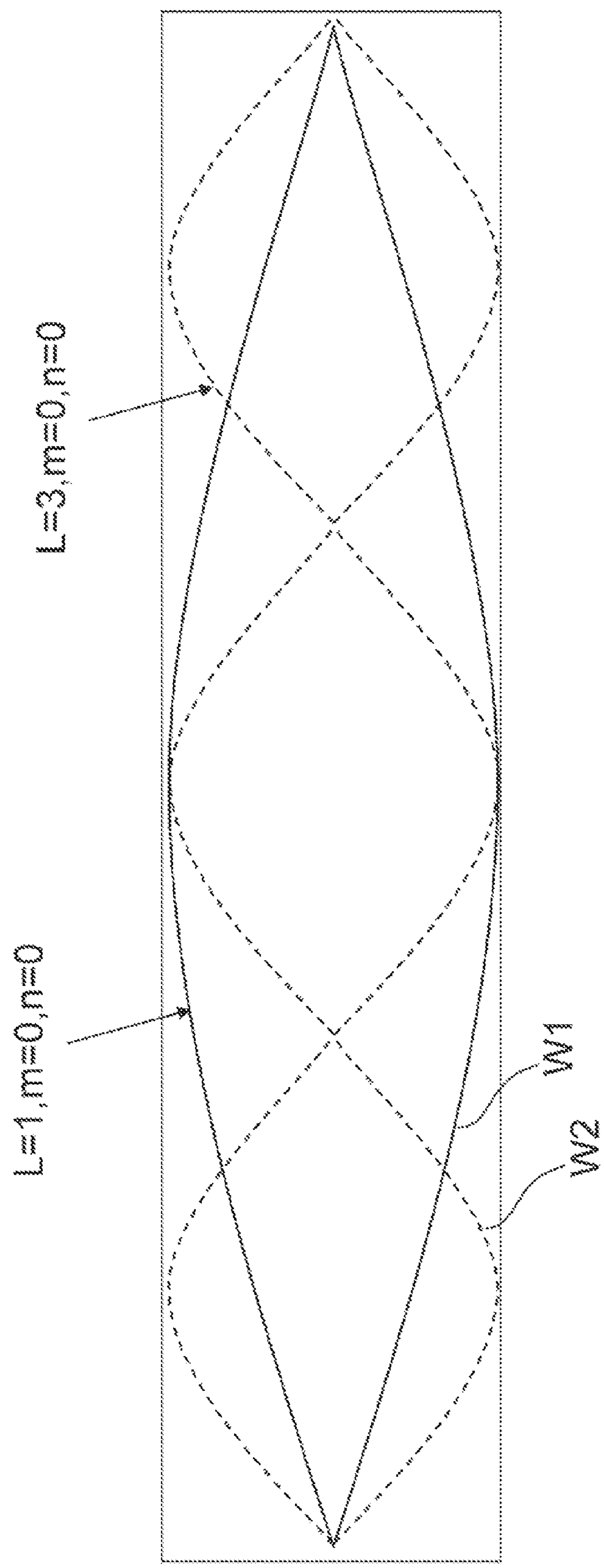


FIG. 4



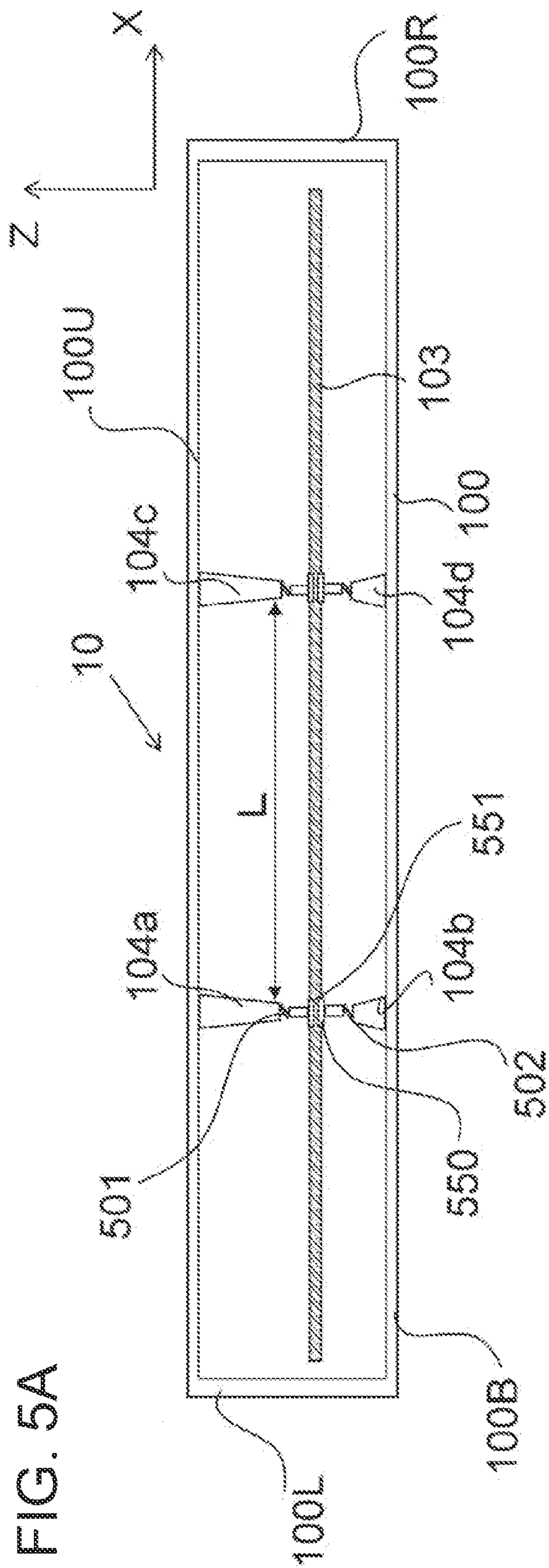

X
Z
100R
100U
103
100
104c
104d
10
L
551
104a
104b
501
502
550
100B
100L

FIG. 5A

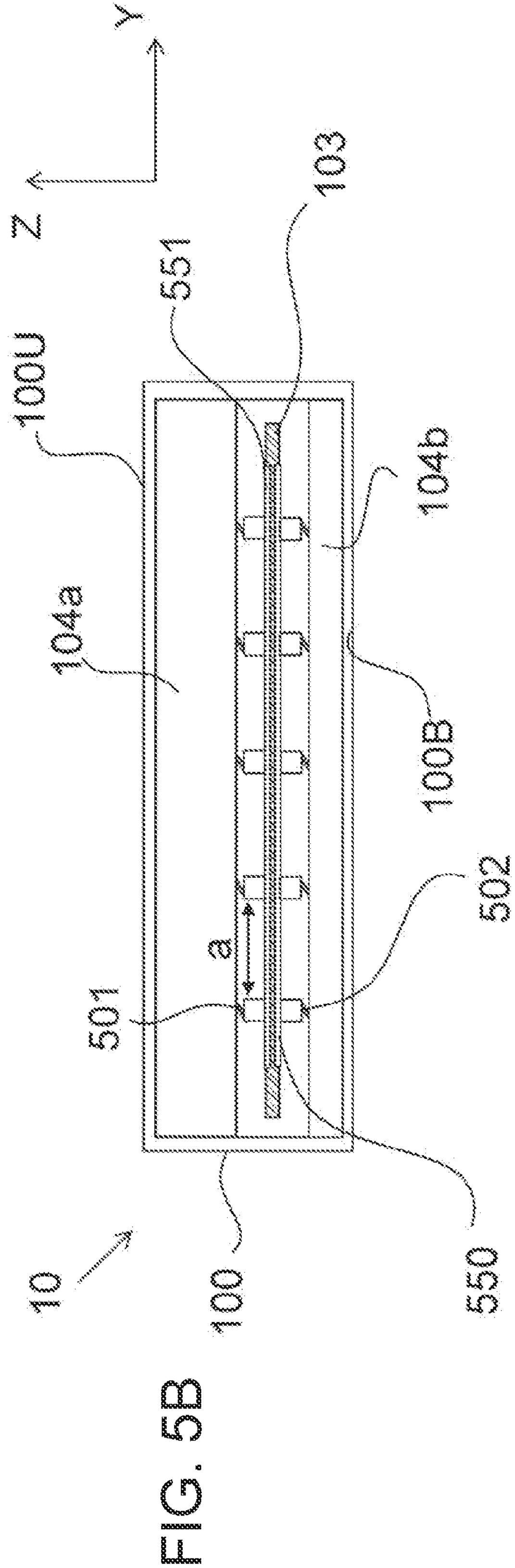
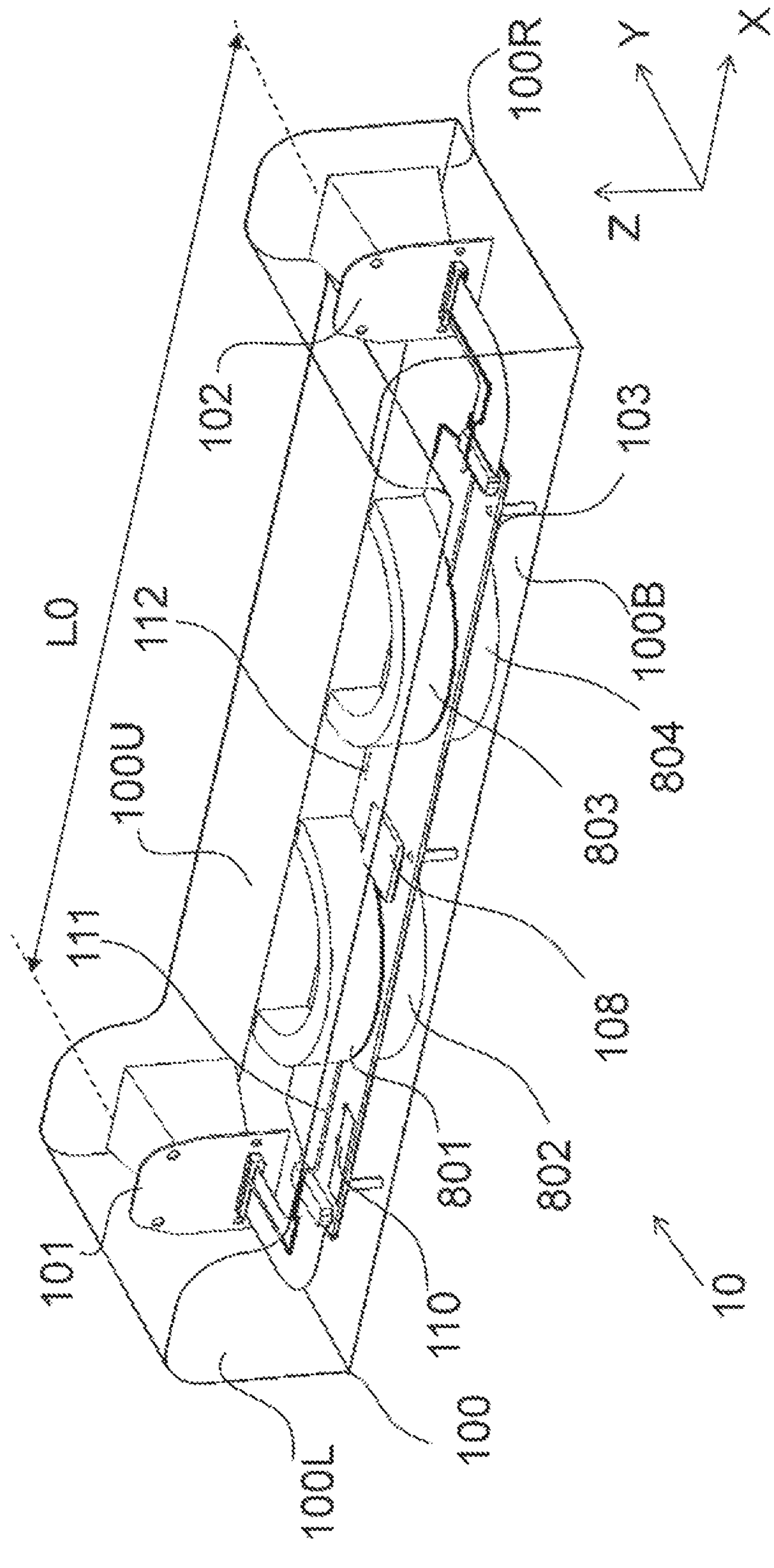

Y
Z
103
551
100U
104b
104a
100B
502
a
501
10
100
550

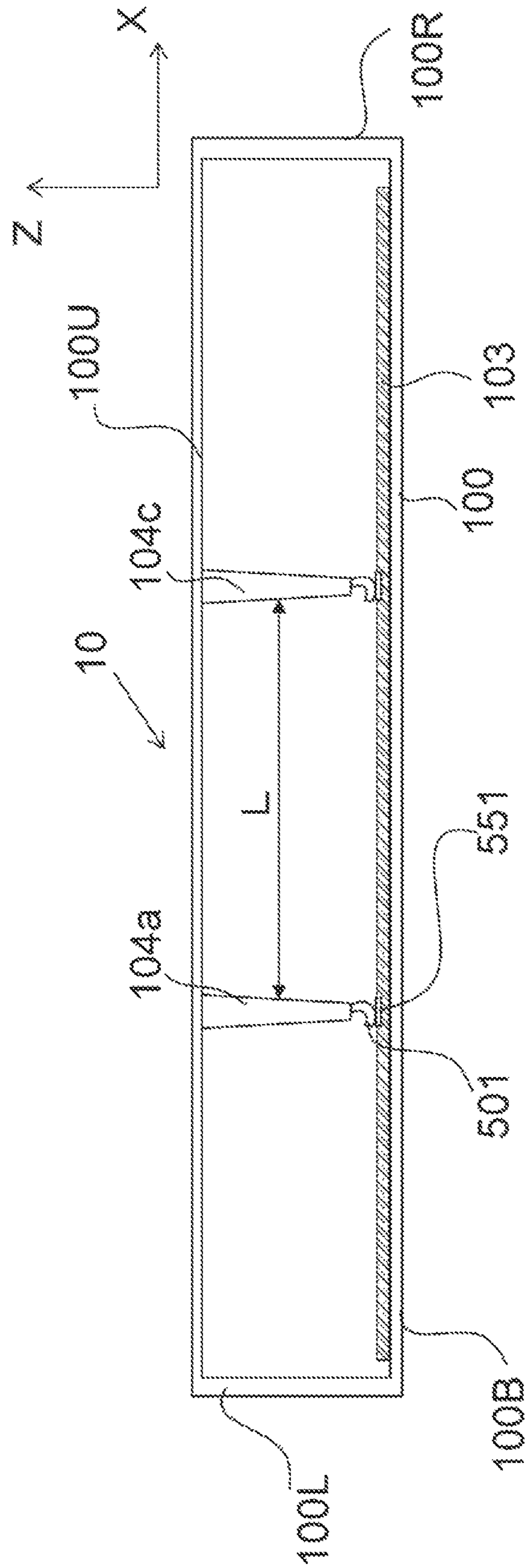
FIG. 5B

FIG. 6



100R
Y
X
Z
102
103
L0
112
100B
804
803
100U
111
108
801
802
101
110
10
100
100L

FIG. 7



STEREO CAMERA DEVICE

TECHNICAL FIELD

The present invention relates to a stereo camera device.

BACKGROUND ART

Conventionally, there is known a camera module having such a structure that a partition plate is provided between an imaging element and an image-processing substrate, and noise generated in the substrate is not transmitted to the imaging element (e.g., PTL 1).

CITATION LIST

Patent Literature

PTL 1: JP 2005-229431 A

SUMMARY OF INVENTION

Technical Problem

However, in the case of a stereo camera in which an imaging element and an image-processing IC are connected to each other through a long signal line, there is a problem that many radiation noises are generate from the signal line due to cavity resonance.

Solution to Problem

A stereo camera device described in claim **1**, including: a casing, a first imaging portion provided on one of ends of the casing in a longitudinal direction of the stereo camera device, a second imaging portion provided on the other end of the casing in the longitudinal direction, a substrate on which a processing circuit connected to the first imaging portion and the second imaging portion through signal lines is mounted, on which a connector for outputting a signal processed by the processing unit to an external device is placed, and which is provided, in the casing, and at least one partition for dividing an interior of the casing into a plurality of spaces in the longitudinal direction at first intervals corresponding to a frequency band which suppresses radiation noise from the signal lines.

Advantageous Effect of Invention

According to the present invention, since a partition is provided, to divide the interior of the casing at the first intervals which correspond to frequency of the radiation noise from the signal line, it is possible to prevent an adverse influence from being exerted on an external device caused by the radiation noise.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view for describing an interior structure of a stereo camera device according to a first embodiment of the present invention.

FIGS. **2**A and **2**B are sectional views of the stereo camera device of the first embodiment.

FIG. **3** is a schematic plan view of an upper surface of a substrate provided in a casing.

FIG. **4** is a diagram for describing cavity resonance in a space divided in the casing.

FIGS. **5**A and **5**B are sectional views of a stereo camera device according to a second embodiment.

FIG. **6** is a perspective: view for describing an interior structure of a stereo camera device according to a third embodiment.

FIG. **7** is a sectional view of a stereo camera device according to a modification.

DESCRIPTION OF EMBODIMENTS

First Embodiment

A first embodiment of a stereo camera device according to the present invention will be described with reference to the drawings. In this description, the stereo camera device which is provided in a vehicle such as a passenger vehicle and which is an externality recognizing sensor used as one of in-vehicle safety devices is described as one example. The stereo camera device measures a distance to an object utilizing a principle of triangulation using images acquired by two imaging portions provided such that the imaging portions are laterally separated from each other by a reference length (e.g., about 200 mm to 400 mm). FIG. **1** is a transmissive schematic perspective view of an interior structure of the stereo camera device according to the first embodiment. The present invention will be described below based on the assumption that a coordinate system composed of an x axis, a y axis and a z axis is set as shown in the drawings.

The stereo camera device **10** includes a metal casing **100**, a first imaging portion **101**, a second imaging portion **102**, a substrate **103**, partition plates **104***a*, **104***b*, **104***c* and **104***d* (when they are collectively called, reference sign **104** is assigned), an image processing IC **108**, a microcomputer **109**, a connector **110** and signal lines **111** and **112**. The casing **100** has such a cylindrical shape that its long side (longitudinal direction) extends in an x-axis direction. While a cross section shape of the casing **100** at a plane intersecting with the x axis at right angles is rectangular in the example shown in FIG. **1**, the cross section shape is determined in associated with an installation place of the stereo camera device **10**, and a circular cross section shape or an elliptic cross section shape are also included in one embodiment of the present invention.

The first imaging portion **101** is formed by mounting an imaging element and an optical lens (both not shown), and the first imaging portion **101** is placed on one of ends (−side of x-axis in FIG. **1**) of the casing **100**. The second imaging portion **102** is formed by mounting an imaging element and an optical lens (both not shown), and the first imaging portion **101** is placed on the other end (+side of x-axis in FIG. **1**) of the casing **100**. That is, the first imaging portion **101** and the second imaging portion **102** are placed in the casing **100** such that the imaging portions **101** and **102** are separated from each other by a reference length L**0** along the x axis which is the longitudinal direction. The first imaging portion **101** and the second imaging portion **102** shoot (take a picture of) a photogenic subject on the y-axis +side, and output, to a later-described image processing IC **1.08**, an analogue image signal produced by photoelectric conversion. The first imaging portion **101** and the second imaging portion **102** configuring the stereo camera device **10** are controlled such that image control and sending and receiving operations of signals are carried out substantially at the same time.

The substrate **103** extends in the x-axis direction, i.e., the longitudinal direction of the casing **100**, and the substrate

103 is placed in the casing **100** by sandwiching the substrate **103** from the +side of z-axis by the partition plates **104***a* and **104***c* and from the −side of z-axis by the partition plates **104***b* and **104***d*. A −side end of x-axis and a +side end of x-axis of the substrate **103** are connected to each other through the first imaging portion **101** and the second imaging portion **102**, a cable or a connector. The image processing IC **108**, the microcomputer **109**, the connector **110**, the signal lines **111** and **112** and various IC (not shown) are provided on the substrate **103**. A circuit GND pattern (wire) or a frame GND pattern (wire) are provided in the y-axis direction at a position where the pattern is connected to the later-described partition plate **104**.

The image processing IC **108** is connected to the first imaging portion **101** through the signal line **111** and connected to the second imaging portion **102** through the signal line **112**. The image processing IC **108** sends and receives various control signals and analog image signals between the first imaging portion **101** and the second imaging portion **102**, converts the received image signal into a digital signal, and calculates a distance to the shot object and a size of the object. The microcomputer **109** is a control circuit which controls the image processing IC **108**. The connector **110** supplies power source to various ICs provided on the substrate **103**, and outputs a shot image and the like processed by the image processing IC **108** to an in-vehicle external device such as a car radio and a navigation system. The signal lines **111** and **112** are places using ends on the substrate **103** as paths such that the signal lines **111** and **112** can avoid the various ICs and wires provided on the substrate **103**. While FIG. **1** shows the example that the image processing IC **108** and the microcomputer **109** are placed in the vicinity of a central portion of the substrate **103**, the places where the image processing IC **108** and the microcomputer **109** are placed are not limited to the example shown in FIG. **1**.

The partition plates **104** are metal plate members provided to prevent, radiation noise from the signal lines **111** and **112** from being transmitted to the external device through the connector **110** and from exerting adverse influence. The partition plates **104***a* and **104***c* are mounted on an upper surface **100**U of the casing **100** through a screw or weld. The partition plates **104***b* and **104***d* are mounted on a bottom surface **100**B of the casing **100** through a screw or weld. Across section of each of the partition plates **104** at a plane which is parallel to a yz-plane is formed into a rectangular shape such that an interior of the casing **100** is divided into a plurality of spaces in the x-axis direction. A length L of each of the plurality of spaces divided by the partition plates **104** in the x-axis direction, i.e., an interval between the partition prates **104***a* and **104***c*, an interval between the partition plates **104***b* and **104***d*, an interval between the side surface **100**L of the casing **100** and the partition plates **104***a* and **104***b*, and an interval between a side surface **100**R of the casing **100** and the partition plates **104***c* and **104***d* are determined in accordance with a frequency band which suppresses radiation noise from the signal lines **111** and **112**. Details of the length L will be described later. Thicknesses of the partition plates **104** are determined such that strength against vibration is secured. The partition plates **104** may integrally be formed together with the casing **100**.

Connection between the substrate **103** and the partition plates **104** will, be described using a sectional view of the casing **100** shown in FIG. **2**. FIG. **2**(*a*) is a sectional view of the casing **100** in an xz-plane, and FIG. **2**(*b*) is a sectional view of the casing **100** in a yz-plane. While the following description is made centering on the partition plates **104***a* and **104***b*, the partition plates **104***c* and **104***d* also have, the same configurations.

As shown in FIG. **2**(*a*), the partition plate **104***a* is connected to a circuit GND pattern or a frame GND pattern (collectively called ground pattern, hereinafter) **550** provided on an upper surface of the substrate **103** through the ground member **501** made of resilient material, such as a spring. A partition plate **104***b* is connected to a ground pattern **551** provided on a lower surface of the substrate **103** through the ground member **502** made of radiation noise such as a spring. In this embodiment, the partition plates **104***a* and **104***b* and the ground members **501** and **502** are integrally formed respectively.

As shown in FIG. **2**(*b*), the plurality of ground members **501** and **502** are provided at predetermined intervals a in a y-axis direction, i.e., a short direction of the casing **100**. That is, the partition plates **104***a* and **104***b* are connected to the substrate **103** in a separated manner at the predetermined intervals a in the y-axis direction. Hence, spaces exist between the substrate **103** and the partition plates **104***a* and **104***b* By setting the predetermined interval a as will be described later, the space between the substrate **103** and the partition plate **104** function as a waveguide, and the waveguide prevents radiation noise of predetermined frequency or less generated from the signal lines **111** and **112** from being transmitted to the external device through the connector **110** and from exerting adverse influence.

As shown in FIG. **2**(*a*) and FIG. **2**(*b*), the ground member **501** of the partition plate **104***a* and the ground member **502** of the partition plate **104***b* are provided substantially on the same straight line in the z-axis direction. Hence, it is possible to enhance a hidden degree of the spaces divided by the partition plates **104***a* and **104***b* in the x-axis direction. Further, the substrate **103** sandwiched between the partition plates **104***a* and **104***b* is sandwiched from the +side and −side of z-axis substantially by the same forces through the ground members **501** and **502** made of resilient material, and it is possible to prevent the substrate **103** from bending.

Radiation noise from the signal lines **111** and **112** will be described below. FIG. **3** is a schematic plan view of the upper surface of the substrate **103** when the interior of the casing **100** is viewed from the +direction of z-axis. As described above, the signal lines **111** and **112** are provided as paths using ends on the substrate **103** such that the signal lines **111** and **112** avoid she various ICs and the wires provided on the substrate **103**. Generally, since the ends of the substrate **103** do not easily take return pass of the GND pattern, noise is prone to be radiated from the signal lines **111** and **112**.

The signal lines **111** and **112** connect, to each other, the image processing IC **108** provided in the vicinity of a central portion of the upper surface of the substrate **103** and the first imaging portion **101** on the +side of the x-axis and the second imaging portion **102** on the −side of x-axis. Hence, as shown in FIG. **3**, wiring paths of the signal lines **111** and **112** have shapes of dipole antenna as described above. To make the first imaging portion **101** and the second imaging portion **102** operate in synchronization with each other, signals are transmitted to the signal lines **111** and **112** substantially at the same time. As a result, the signal lines **111** and **112** function as dipole antenna, and noise is prone to be generated.

Noises generated by the signal lines **111** and **112** occur resonance phenomenon in the space of the cylindrical, casing **100** having the long side in the x-axis direction, and become noises (radiation noises) having high frequency (resonance frequency). When this radiation noise is transmitted to the connector **110** and is discharged to the outside of the stereo camera device **10** or the radiation noise leaks to outside from a gap of the casing **100**, the radiation noise exerts adverse influence on the operation of the in-vehicle external device depending upon frequency of the radiation noise.

In this embodiment, by dividing the space in the casing **100** using the partition plates **104**, the frequency of the radiation noise is brought into cavity resonance frequency f**1** of a frequency band which is higher than a frequency band having the possibility of adverse influence exerted on the operation of the external device, and influence on the operation of the external device, is lowered. In other words, the length L of the space divided in the casing **100** in the x-axis direction is determined such that frequency becomes the cavity resonance frequency f**1** which does no exert adverse influence on the operation of the external device.

The cavity resonance frequency f1 is indicated by the following equation (1).

$$f1=1.50\{(1/L)^2+(m/M)^2+(n/N)^2\}^{1/2}\text{ [MHz]} \quad (1)$$

wherein L, M and N are lengths of the divided spaces in the x axis, the y axis and the z axis. Further, l, m and n shows the number of half wavelengths in the spaces divided in the casing **100**.

Since, the casing **100** is of the structure having the long side extending along the x-axis, the length in the x-axis direction is predominant. Hence, the cavity resonance frequency f1 can be expressed by the following equation (2) which is similar to the equation (1). As shown in equation (2), the smaller the length L of the divided space becomes, the higher the cavity resonance frequency f1 becomes.

$$f1\approx 150\times(1/L)\text{ [MHz]} \quad (2)$$

A waveform W**1** shown by a solid line in FIG. **4** shows one half wavelength forming one node in the space. In this case, l=1, m=0 and n=0. Waveforms W**2** shown by a broken line show three half wavelengths forming three nodes in the space. In this case, l=3, m=0 and n=0. As shown in FIG. **2**, the greater the number of half wavelengths increases, the higher the cavity resonance frequency f1 becomes. That is, the greater the number of half wavelength, becomes, the higher the cavity resonance frequency f1 becomes. The number of half wavelengths is determined in accordance with a vehicle installation when the stereo camera device **10** is installed. The following description is based on such an example that when the cavity resonance frequency f**1** is set to a high frequency band, the number of half wavelength having the severest condition is set to one, i.e., l=1.

As a frequency band having the possibility of adverse influence exerted on the operation of the external device is taken into consideration, the cavity resonance frequency f**1** of radiation noise is set to not less than certain frequency (e.g., about 3 [GHz]) which is higher than the highest frequency of a noise spec of each of the external devices. In this case, by inversely calculating equation (2) while setting l to one, the length L of the divided space in the x-axis direction is set to 5 [cm] or less. That is the partition plates **104**_a_, **104**_b_, **104**_c_ and **104**_d_ are provided in the casing **100** such that the interval between the partition plates **104**_a_ and **104**_c_ in the x-axis, the interval between the partition plates **104**_b_ and **104**_d_ in the x-axis, the interval between the side surface **100**L of the casing **100** and the partition plates **104**_a_ and **104**_b_ in the x-axis direction, and the interval between a side surface **100**R of the casing **100** and the partition plates **104**_c_ and **104**_d_ in the x-axis direction shown in FIG. **2** become 5 [cm] or less. However, it is preferable that the lower limit of the interval in the x-axis be determined while taking into consideration, costs of the partition plates **104**, installation of the various ICs and parts on the substrate **103** and difficulties of pattern design.

By determining the length L of the space as described above, the cavity resonance frequency f**1** becomes a frequency band higher than a frequency band which exerts adverse influence on the external device. Hence, even if radiation noise which becomes the cavity resonance frequency f**1** is discharged outside of the stereo camera device **10** through the connector **110** or the radiation noise leaks to outside from the gap of the casing **100**, adverse influence is not exerted on the operation of the external device.

The above description is based on the example that the interior of the casing **100** is divided into the three spaces by the partition plates **104**. However, the number of divided spaces, i.e., the number of the partition plates **104** provided in the casing **100** differs depending upon radiation noises from the signal lines **111** and **112** and the length of the casing **100** in the x-axis direction.

The partition plates **104** are connected to the substrate **103** at the predetermined interval a in the y-axis such that the partition plates are separated from the substrate **103** as described above. According to this, the spaces existing between the partition plates **104** and the substrate **103** in the z-axis direction function as waveguides. In this case, frequency f**2** of radiation noise which is cut off by the spaces existing between the partition plates **104** and the substrate **103** (cutoff frequency f**2**, hereinafter) is shown by the following equation (3).

$$f2=c/2a \quad (3)$$

wherein c is speed of light.

The cutoff frequency f**2** is a frequency band having nothing to do with the operation of the stereo camera device **10**. The cutoff frequency f**2** is set to a frequency component which does not reach the cavity resonance frequency f**1** by the partition plates **101** and especially, the cutoff frequency f**2** is set to a frequency band having the possibility of adverse influence exerted on the external device. That is, it is preferable that the cutoff frequency f**2** be set to a value smaller than the cavity resonance frequency f**1**.

The predetermined interval a is determined based on the equation (3) so that such cutoff frequency f**2** is obtained. That is, the predetermined interval a is determined such that radiation noise from the signal lines **111** and **112** which is equal to or less than the cutoff frequency f**2** is cut off, and the radiation noise which is equal to or less than the cutoff frequency f**2** is prevented from passing from the spaces. As a result, radiation noise from the signal lines **111** and **112** includes a frequency band exerting adverse influence on the external device is cut off. This configuration prevents radiation noise from the signal lines **111** and **112** from being transmitted to the external device through the connector **110** and from exerting di.

The example shown in FIG. **2**(_b_) shows a case where five ground members **501** and **502** are provided respectively. However, the number of ground members **501** and **502** is determined in associated with the predetermined interval a, and it is preferable that at least one pair of ground members **501** and **502** be provided respectively.

According to the stereo camera device of the first embodiment, the following function effects are obtained.

(1) The stereo camera device includes the partition plates **104** dividing the interior of the cylindrical casing **100** into the plurality of spaces in the longitudinal direction at an

interval corresponding to a frequency band suppressing radiation noise from the signal lines **111** and **112** which connect, to each other, the first imaging portion **101**, the second imaging portion **102** provided on both ends in the longitudinal direction and the image processing IC **108**. This interval is determined such that the cavity resonance frequency f**1** of a frequency band becomes higher than a frequency band of noise radiated from the signal lines **111** and **112**. As a result, even if radiation noise is transmitted to the connector **110** or the radiation noise is discharged outside of the stereo camera device **10** through a harness of the radiation noise leaks to outside from the gap of the casing **100**, it is possible to prevent the radiation noise from exerting adverse influence on the operation of the in-vehicle external device. Generally, as frequency of electromagnetic wave is higher, the electromagnetic wave is more prone to be attenuated. Therefore, it is possible to contribute to attenuation of radiation noise by bringing the cavity resonance frequency f**1** into a high frequency band. Further, as compared with a countermeasure example in which radio wave absorbent sheets are pasted on the casing **100** and the image processing IC **108** or a gasket is provided in the gap of the casing **100**, since it is possible to prevent influence of radiation noise from exerting from exerting on the external device with a simple structure, this configuration also contributes to reduction of costs.

(2) The partition plates **104***a* and **104***c* provided on an inner wall of the upper surface **100**U of the casing **100** are connected to each other through the ground pattern **550** and the ground member **501** provided on the upper surface of the substrate **103**, and the partition plates **104***b* and **104***d* provided on an inner wall of the bottom surface **100**B of the casing **100** are connected to each other through the ground pattern **551** and the ground member **502** provided on the lower surface of the substrate **103**. Hence, since the casing **100** and the circuit GND pattern or the frame GND pattern of the substrate **103** can be connected to each other, it is possible to lower the impedance of GND, and to obtain a noise reduction effect on the substrate **103**.

(3) The partition plates **104***a* and **104***c* are connected to each other through the ground pattern **550** on the upper surface of the substrate **103** and the ground member **501** made of resilient material, and the partition plates **104***b* and **104***d* are connected to each other through the ground pattern **551** on the lower surface of the substrate **103** and the ground member **502** made of resilient material. Hence, since substantially the same forces are applied to the substrate **103** from the +side and −side of z-axis, it is possible to prevent inconvenience that the substrate **103** bends.

(4) Each of the lengths L, in the x-axis direction, of the spaces divided by the partition plates **104** is set as a distance which cavity-resonates noise generated by the signal lines **111** and **112**, and which brings the frequency of the noise into a frequency band higher than a noise frequency band that is prescribed by the external device. As a result, since the resonance frequency f**1** of radiation noise becomes higher than a frequency band which exerts adverse influence on the external device, even if the radiation noise is discharged outside of the stereo camera device **10** through the connector **110** or the radiation noise leaks to outside from the gap of the casing **100**, adverse influence is not exerted on the operation of the in-vehicle external device.

(5) The ground members **501** and **502** are connected to each other along the y-axis at predetermined interval a which correspond to radiation noise from the signal lines **111** and **112**. In this case, the predetermined interval a is set such that radiation noise having the cutoff frequency f**2** which is smaller than the cavity resonance frequency f**1** can be cut off. As a result, it is possible to prevent radiation noise having frequency which is equal to or less than the cutoff frequency f**2** having the possibility that adverse influence is exerted on the external device from passing through the space existing in the z-axis direction between the partition plates **104** and the substrate **103**. Therefore, it is possible to prevent the radiation noise from the signal lines **111** and **112** from being transmitted to the external device through the connector **110** and from exerting adverse influence on the external device.

Second Embodiment

A second embodiment of the stereo camera device according to the present invention will be described with reference to drawings. In the following description, the same reference signs are allocated to the same constituent element as those of the first embodiment, and differences will mainly be described. Points which are not especially described are the same as the first embodiment. In the first embodiment, the ground member which is integrally formed together with the partition plate, and the partition plate and the substrate are connected to each other. The second embodiment is different from the first embodiment in that a ground member and a partition on plate soldered to a substrate are connected to each other.

FIG. **5**(*a*) and FIG. **5**(*b*) are sectional views of a casing **100** of a stereo camera device **10** in the second embodiment. FIG. **5**(*a*) is a sectional view in an xy-plane of the casing **100**, and FIG. **5**(*b*) is a sectional view in a yz-plane of the casing **100**. While the following description is made centering on partition plates **104***a* and **104***b*, partition plates **104***c* and **104***d* also have the same configurations.

As shown in FIG. **5**(*a*) and FIG. **5**(*b*), a lower end (−side of z-axis) of each of the ground members **501** made of resilient material such as a spring is soldered to a ground pattern **550** such as a circuit GND pattern and a frame GND pattern provided on an upper surface of a substrate **103**. An upper end (+side of z-axis) of the ground member **501** is connected to a lower end of a partition plate **104***a*. An upper end (aside of z-axis) of the ground member **502** made of resilient material such as a spring is soldered to a ground pattern **551** provided on a lower surface of the substrate **103**. A lower end (−side of z-axis) of the ground member **502** is connected to an upper end of the partition plate **104***b*.

The ground members **501** of the partition plates **104***a* and the ground members **502** of the partition plate **104***b* are the same as the stereo camera device **10** of the first embodiment in that the ground member **501** and the ground member **502** are provided substantially on the same straight line in the z-axis direction, and in that the ground members **501** and the ground members **502** are provided at predetermined interval a in the y-axis direction. According to the stereo camera device **10** of the second embodiment having the above-described connecting manner also, the same function effects as the stereo camera device of the first embodiment can be obtained.

Third Embodiment

A third embodiment of the stereo camera device according to the present invention will be described with reference to a drawing. In the following description, the same reference signs are allocated to the same constituent elements as those of the first embodiment, and differences will mainly be described. Points which are not especially described are the same as the first embodiment. In the third embodiment, a shape of a partition plate is different from that of the partition plate of the first embodiment in which the partition plate is formed into a rectangular plane which is parallel to a yz-plane

FIG. **6** is a perspective view for describing, in a transmissive manner, an interior structure of the stereo camera device **10** according to the third embodiment. As shown in FIG. **6**, partition plates **801** to **804** are formed such that cross sections thereof are formed into arc shapes at planes which are parallel, to an xy-plane. Even when the partition pates **801** to **804** have the shapes shown in FIG. **6**, an interior of the casing **100** is divided into a plurality of spaces by the partition plates **801** to **804** and a wall surface of the casing **100**. In this embodiment, inner diameters of the arc-shaped partition plates **801** to **804** and distances of partition plates which are adjacent to each other in the x-axis direction are determined based on the above-described equation (2). As a result, in the spaces divided by the partition plates **801** to **804**, noise generated by signal lines **111** and **112** becomes radiation noise having cavity resonance frequency f1 by the resonance phenomenon. The partition plates **801** to **804** and the substrate **103** are connected to each other in the same manner as the first embodiment or the second embodiment. According to the stereo camera device **10** of the third embodiment having the above-described connecting manner also, the same function effects as the stereo camera device of the first embodiment can be obtained.

Shapes of cross sections of the partition plates **801** to **804** which are parallel to the xy-plane are not limited to the arc shapes, and as the cross sections, various shapes such as triangular shapes and stair shapes are included. It is preferable that the cross section shape can avoid installation positions of the various ICs provided on the substrate **103**.

The following modifications are also within the scope of the present invention, and one of the modifications may be used alone or a plurality of modifications may be combined with the above-described embodiments.

(1) Instead of the structure in which the partition plates **104** are provided on an inner will of the upper surface **100**U of the casing **100** and an inner wall of the bottom surface **100**B and the substrate **103** is sandwiched between the +side of z-axis and the −side of z-axis, it is also possible to employ a structure that the partition plates **104** are provided on one of the inner wall of the upper surface **100**U of the casing **100** and die inner wall of the bottom surface **100**B. For example, when a mounted product is not provided on the lower surface of the substrate **103**, the substrate **103** may be fixed to the inner wall of the bottom surface **100**B of the casing **100** through a screw of the like, and the lower end of the partition plates **104** provided on the inner wall of the upper surface **100**U of the casing **100** and the upper surface of the substrate **103** may be connected to each other as shown in FIG. **7**.

(2) Instead of the structure that the partition plate **104** and the ground patterns **550** and **551** provided on the substrate **103** are connected to each other through, the ground members **501** and **502**, the partition plate and the ground patterns **550** and **551** of the substrate **103** may directly be connected to each other. In this case, it is preferable that the end of the partition plate on the side of the substrate **103** be processed into such a shape that a space of the predetermined interval a is formed.

(3) The stereo camera device **10** is not limited to the in-vehicle stereo camera provided in a vehicle, and the stereo camera device **10** may be used in a stereo camera provided in a moving body such as a construction machine and a railroad vehicle, and an industrial robot.

The present invention is not limited to the above-described embodiments unless the feature of the invention are not damaged, and other modes which are considered within a scope of technical idea of the invention is also included in the scope of the invention.

REFERENCE SIGNS LIST

10 stereo camera device
100 casing
101 first imaging portion
102 second imaging portion
103 substrate
104, **801**, **802**, **803**, **804** partition plate
108 image processing IC
109 microcomputer
110 connector
111, **112** signal lines
501, **502** ground member
550, **551** ground pattern

The invention claimed is:

1. A stereo camera device, comprising:
- a casing;
- a first imaging portion provided on one of ends of the casing in a longitudinal direction of the stereo camera device,
- a second imaging portion provided on the other end of the casing in the longitudinal direction;
- a substrate on which a processing circuit connected to the first imaging portion and the second imaging portion through signal lines is mounted, on which a connector for outputting a signal processed by the processing unit to an external device is placed, and which is provided in the casing; and
- at least one partition for dividing an interior of the casing into a plurality of spaces in the longitudinal direction at first intervals corresponding to a frequency band which suppresses radiation noise from the signal lines,
- wherein the at least one partition includes a first partition member provided in an inner wall of an upper surface of the casing in a short direction of the stereo camera device, and a second partition member provided on an inner wall of a lower surface of the casing in the short direction,
- wherein the first partition member is connected to a ground wire provided on an upper surface of the substrate through a first ground member,
- wherein the second partition member is connected to a lower surface of the substrate through a ground wire provided on a second ground member, and
- further comprising at least one more first ground member and one more second ground member, wherein a second interval between the pair of ground members is determined as a value corresponding to radiation noise from the signal line.

2. The stereo camera device according to claim **1**, wherein the first and second ground members are resilient members which are respectively interposed between the ground wire of the upper surface of the substrate and the ground wire of the lower surface and the first and second partition members.

3. The stereo camera device according to claim **1**, wherein the first interval is set as a distance which cavity-resonates the radiation noise and which brings frequency of the radiation noise into a frequency band higher than a noise frequency band prescribed by the external device.

4. The stereo camera device according to claim 1, wherein the second interval is set as a distance capable of cutting off radiation noise having frequency which is smaller than cavity resonance frequency that is determined by the first partition member and the second partition member provided at the first interval.

* * * * *